ECE 305 – Spring 2018

Homework 7 – Due Tuesday, March 20, 2018 at 12:00 PM in class (or in EE 326B)

1. Assume that we have a solar cell consisting of a one-sided pn junction, where the lightly-doped (n-type) side has doping N_D=10^{17} /cm^3, width $W_N = 10$ μm, minority carrier μ_p=450 cm^2/V·s and minority carrier τ_p=1 μs. The other side has doping N_A=3·10^{18} /cm^3, width $W_P = 15$ μm, minority carrier μ_n=1400 cm^2/V·s, and minority carrier τ_n=3 μs. The short circuit current per unit area $J_{sc} = 28$ mA/cm^2 under AM1.5 illumination ($P_{in} = 100$ mW/cm^2), and ideality factor $n = 1$. All values are at room temperature.

    a. Calculate the dark current per unit area.

    b. Calculate the open-circuit voltage of this cell.

    c. Sketch the current-voltage relation for this solar cell in the power-producing quadrant (i.e., when $0 \leq V \leq V_{oc}$), with voltage on the x-axis. Be sure to label the x and y-axes and include at least two specific numerical values.

    d. Estimate the fill factor. Hint: use $\mathrm{FF} = \frac{z_{oc} - \ln(z_{oc}+0.72)}{z_{oc}+1}$, where $z_{oc} = qV_{oc}/nk_BT$ is the reduced open-circuit voltage.

    e. Calculate the power conversion efficiency.

2. An ideal rectifying metal-semiconductor contact has a Schottky barrier of 0.5 eV and built-in voltage $V_{bi} = 0.3$ eV at room temperature. Assume that the semiconductor is n-type gallium arsenide ($\chi = 4.07$ eV, $K_s = 12.9$).

    a. Calculate the metallic workfunction Φ_M.

    b. Calculate the doping of the gallium arsenide.

    c. Calculate the depletion width W (for $V_A = 0.2$ V).

    d. Calculate the maximum electric field $\mathcal{E}(0)$ (for $V_A = 0.2$ V)

    e. Assuming that the critical breakdown field $\mathcal{E}_{cr} = 4 \cdot 10^5$ V/cm (in the GaAs), what are the corresponding values of V_A and V_R at which breakdown would be expected?